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1980 BRISTOL BAY SOCKEYE SALMON SMOLT STUDIES

Edited by:
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Subport Building, Juneau, Alaska 99801

Ronald O. Skoog
Commissioner

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Data presented in these reports is intended to be final, however, some revisions may occasionally be necessary. Minor revisions will be made via errata sheets. Major revisions will be made in the form of revised reports.

1980 BRISTOL BAY SOCKEYE SALMON SMOLT STUDIES

A summary of data collected from sockeye salmon, *(Oncorhynchus nerka)* smolt programs in Bristol Bay including Kvichak, Wood, and Snake Rivers

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1981

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BRISTOL BAY SOCKEYE SALMON STUDIES

ABSTRACT

Sockeye salmon *(Oncorhynchus nerka)* smolt projects were conducted on three Bristol Bay rivers in 1980. Estimates of outmigrating sockeye salmon smolt were 172.7 million from the Kvichak, 48.3 million from the Wood, and 2.0 million from the Snake River system. Age composition was 94% Age I and 6% Age II smolt from the Kvichak, 96% Age I and 4% Age II from the Wood, and 99% Age I and 1% Age II from the Snake River.

INTRODUCTION

This Technical Data Report represents a continuation in the documentation of sockeye salmon smolt data collected from various Bristol Bay river systems. In 1980, smolt projects were conducted on three systems, Kvichak, Wood, and Snake. Sonar biomass counters were used to estimate smolt abundance on the Kvichak and Wood Rivers while a fyke net program was used on the Snake River. Length and weight data were collected from each age class of smolt on each of the three rivers sampled. Infection rate by *T. crassus* was documented for smolt emigrating down the Wood River. Climatological data are presented for each smolt site.

Smolt data is used to forecast returns of adults and to assist in establishing optimum escapement levels. These data are also used in assessing the effects of salmon rehabilitation and enhancement projects located in the Wood and Snake River systems.

As used in this report, Age I smolt refer to smolt in their second year of freshwater residency at the time of outmigration and possessing one winter scale annulus. Age II smolt refer to those smolt in their third year of freshwater residency and possessing two winter scale annuli.

1980 KVICHAK RIVER SOCKEYE SALMON SMOLT STUDIES

By

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INTRODUCTION

Data on age composition, size, and numbers of Kvichak River sockeye salmon smolt migrating to sea are used in forecasting the age composition and numbers

of subsequent adult returns to the Naknek/Kvichak fishery and to evaluate escapement levels and smolt production. Total smolt outmigration estimates from sonar enumeration began in 1971, replacing outmigration indices estimated from fyke net catches which were initiated in 1955 (Russell 1972; Paulus and McCurdy 1972; Parker 1974a and 1974b). Collection of smolt age and size data as well as sonar enumeration of the Kvichak River smolt outmigration continued in 1980.

METHODS AND MATERIALS

Sonar Arrays

Installation and operation of the sonar counting system was similar to that of 1976 with the few changes noted below (Randall 1977). The system consisted of three 3.2 m plastic ladder arrays, each holding 14 sonar transducers. Each array was independently anchored. The transducers were attached to the arrays and their cables gathered together into three separate bundles of 100 m in length which were connected to a single control unit housed in a tent on the river bank.

On 16 May 1980 the inshore and center arrays were placed in the river. Heavy ice flow from the lake followed soon afterward, delaying deployment of the offshore array. The center array anchor dragged downstream and was operated intermittently because of efforts to reposition it. Ice hampered the operation until 1200 hours 21 May when all 3 arrays were in position and became fully operational. The daily counts over the offshore array and center array prior to 21 May were interpolated by applying the average proportion of counts between the inshore and the other two arrays during the entire season to the inshore array count when the other two arrays were not operational.

Adjustment of Sonar Counts

The system was monitored 24 hours per day. Every 15 minutes counts were electronically totaled for each array and recorded on paper tape. To interpret the sonar counts as smolt, the following adjustments were required: subtract false counts, interpolate for missed time, adjust for river velocity, expand counts for river width, and multiply by 10.

Known false counts caused by wind, rain, ice, boats, etc., were subtracted from the counts printed on the paper tape. The normal procedure, however, was to disable to entire system when a known source of false counts appeared, e.g., boats, ice, etc. The control unit printed the number of seconds the system was disabled. Counts during missed time were estimated by linear interpolation. The control unit was temperature sensitive and there was approximately a 3% error in the disable time printed on the paper tape during the first 5 days of the project. The actual disable time was less than the disable time printed by the control unit. After 20 May this error was negligible, and no adjustment was made in the expanded outmigration counts. During the same time period a difference was also noticed between the printed counts and the number tallied on the control unit totalizers. The printed counts were approximately 5% lower than the totalizer counts. Since the printer

was more accurate than the totalizers, the only error occurred in the number of false counts tallied by the totalizers. This error was considered negligible, therefore, no adjustment was made in the outmigration estimate.

The counting rate of the control unit was dependent on water velocity. The control unit was initially set at 5.40 fps and reset to 5.20 fps on 20 May for the remainder of the project. Actual water velocities were measured with a Gurley meter over the inshore and center arrays five times, and over the offshore array four times during the project. Average velocities were 5.32, 5.74, and 5.70 fps over the inshore, center, and offshore arrays, respectively. These water velocities were used to make linear adjustments in the sonar counts.

The counts from each array were expended to estimate the number of smolt migrating in sections of the river not covered by the arrays. The sonar signal from each array was approximately 3.7 m wide. The surface width of the river was measured at 85 m. A side scanning sonar system was used to determine the limits of the lateral distribution of smolt in the river. Based on data obtained from the side scanning sonar, smolt did not utilize the first 14 m from the west bank nor the first 8 m from the east bank. Figure 1 illustrates the position of the arrays in the river and this season's lateral smolt distribution across the river. Daily counts were then expanded to estimate the total daily outmigration based on the daily lateral distribution of sonar counts over the three arrays. Mean expansion factors derived from the area under the lateral distribution curve were 5.65, 3.85, and 4.13 for the inshore, center, and offshore sector, respectively.

The sonar system functioned as a biomass counter and was designed to register one count for the biomass equivalent to 10 smolt passing over the sonar equipped arrays (Krasnowski 1975). Daily counts were therefore multiplied by 10 as the final adjustment in estimating the numbers of outmigrating smolt. A sample of a completed daily outmigration estimate with adjustments for disable time, water velocity, expansion for unsonified areas, and multiplication by 10 fish per count was presented by Randall (1977).

Age-Weight-Length Sampling

Samples from fyke net catches were used to determine mean lengths, weights, and age composition of the outmigrating smolt. A standard 1.2 x 1.2 m fyke net was fished in about 1.2 m of water in approximately the same location as the index site of previous years. An effort was made to collect 30 smolt for age, length, and weight data at 0600, 1200, 1800, and 2400 hours daily. The estimated age proportion was 94% Age I[1] and 6% Age II, therefore, the smolt age samples were pooled into sample sizes of 60 fish or more which allowed detection of a 5% change in the age composition at the 95% confidence limit (Snedecor and Cochran 1967).

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[1] In second year of freshwater residency - one winter annulus.

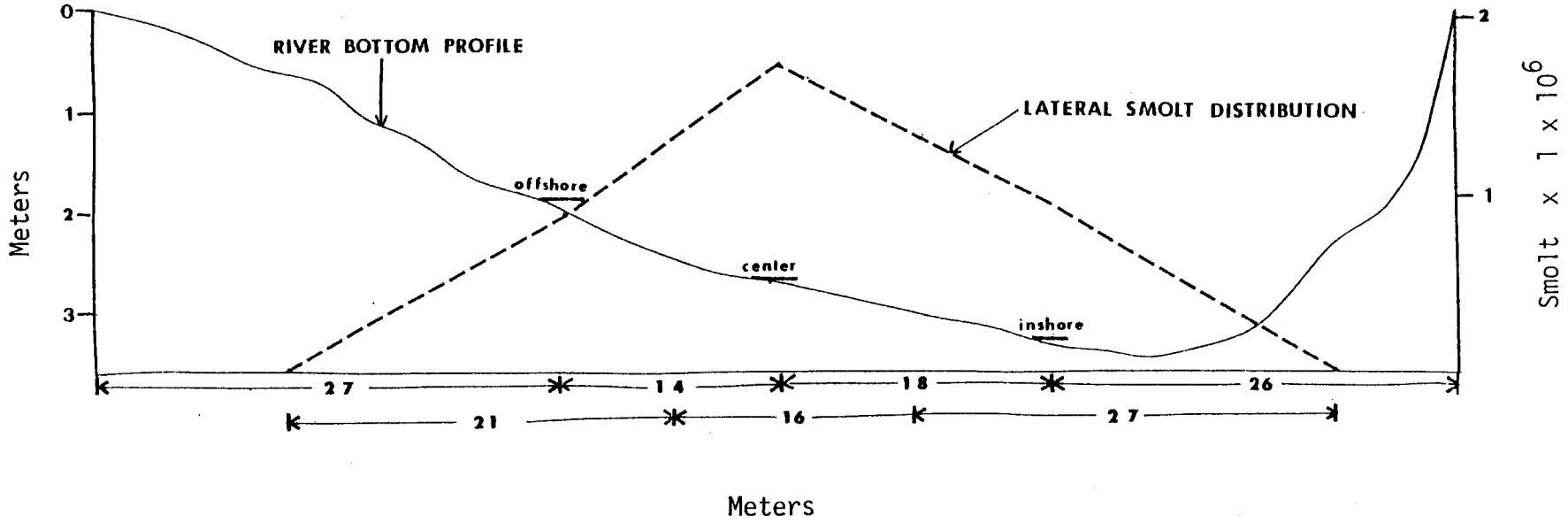

Figure 1. River bottom profile at sonar site, location of arrays and estimated lateral smolt distribution, Kvichak River, 1980.

As a result there were 18 sample periods between 1 to 9 days each. Estimated age composition of the total outmigration was weighted by the outmigration estimate for each of the sample periods. Estimated mean length and weight for the entire outmigration was obtained by summing the daily mean lengths and weights, also weighted by the corresponding daily outmigration estimate.

RESULTS

Climatological and Hydrological Observations

Weather and river conditions were recorded at the sonar site from 16 May through 18 June 1980 (Table 1). There was heavy ice flow from 16 May to 20 May. Over the duration of the project, the mean air and water temperatures were 12.1 and 5.5°C, respectively. Water temperatures during the smolt studies in the past 18 years have averaged 5.13°C. Water temperature data from 1963 to 1980 are presented in Appendix Table 1. During the peak of the outmigration, 26-28 May, the mean water temperature was 5.25°C. The water level rose approximately 0.5 m during the project.

Outmigration Estimate

A total of 3,616,280 sonar counts was talled during the 1980 sonar enumeration project (Table 2). This lead to an estimated outmigration of 172.7 million smolt (Table 3). The peak of the outmigration occurred between 26 May and 28 May and represented 39% of the total outmigration. Figure 2 illustrates the daily outmigration estimate for 1980. There were 162.6 million Age I smolt enumerated from the 1978 escapement of 4.1 million spawners. This was nearly twice the prior largest Age I smolt outmigration since 1969. The remaining 10.1 million smolt were Age II and were the progeny of 1.3 million adults spawning in 1977. The 10.1 million Age II smolt added to 26.6 million Age I smolt that emigrated in 1979 equal a total production of 27.4 smolt per spawner from the 1977 brood year (Table 4). Smolt to adult marine survival has been calculated for Age I and Age II smolt from brood year 1968 through brood year 1976 (Table 5). Average marine survival for Age I smolt is 8.3% and for Age II smolt is 13.1%.

Age-Weight-Length

A total of 1,971 smolt was measured to determine mean weight, length, and age. Daily mean weights and lengths are presented in Table 6. The estimated age composition of the total outmigration was 94% Age I and 6% Age II. The estimated mean weights of the total outmigration were 5.9 g for Age I smolt (20 year mean = 6.0 g) and 10.7 g for Age II smolt (20 year mean = 11.1 g). Mean lengths were 88.4 mm for Age I smolt (20 year mean = 88.8 mm) and 109.9 mm for Age II smolt (20 year mean = 109.3 mm). Appendix Table 2 provides smolt age composition, weight, and length data for the years 1955 through 1980.

Table 1. Climatological and stream observations, Kvichak River, 16 May - 18 June 1980.

Date	Sky 0800	Sky 2000	Wind (MPH) Direction 0800	Wind (MPH) Direction 2000	Air Temp. °C Max.	Air Temp. °C Min.	Water Temp. °C 0800	Water Temp. °C 2000	Precipitation (cm) 24 hrs.	Water Level [1] (m) 0800 hr.	Turbidity 0800 hr.
5/16	3	2		10SE	24	2	2.5		0	2.97	1
5/17	3	4	20NE	5NE	24	4	2.0		0	3.03	2
5/18	3	4	10SE	15NE	22	4	1.5		.89	3.00	2
5/19	4	3	4NE	Calm	15	3	1.5	2.0	0	2.97	2
5/20	3	3	Calm	8SW	18	0	2.0		0	2.97	2
5/21	4	3	10SW	10SW	24	6	2.5		0	2.97	1
5/22	4	4	4SW	Calm	24	6	3.0	4.0	0	3.05	1
5/23	4	4	3NE	25NE	23	5	4.0	5.0	T	3.07	1
5/24	4	3	13NE	4NE	17	4	4.0	5.5	.30	3.09	2
5/25	4	4	3NE	8NE	14	4	5.0	5.5	T	3.07	2
5/26	4	3	11NE	Calm	22	3	5.5	5.0	.36	3.10	2
5/27	3	4	3NE	3NE	20	4	5.0	5.0	0	3.07	2
5/28	4	4	Calm	3NE	14	4	5.5	5.5	.99	3.11	1
5/29	4	3	6NE	8NE	16	5	5.0	5.5	T	3.07	1
5/30	4	4	13SW	13SW	9	5	5.0	5.0	.66	3.06	2
5/31	3	1	10SW	5SW	24	1	5.0	5.5	.10	3.27	1
6/01	1	4	Calm	Calm			5.0	6.0	.15	3.29	1
6/02	4	2	Calm	3NE	22	1	5.5	7.0	0	3.29	1
6/03	4	3	5NE	3NE	16	8	7.0	7.5	T	3.29	1
6/04	3	4	Calm	3SW	24	6	7.0	8.0	0	3.29	1
6/05	4	4	3NE	7SW	24	1	7.0	7.0	.36	3.29	1
6/06	4	4	3NE	8SW	12	8		7.0	1.19	3.31	1
6/07	3	2	3SW	3SW	17	5	6.0	7.0	.05	3.33	1
6/08	1	3	8S	3SW	18	6	6.0	7.0	0	3.35	1
6/09	4	4	Calm	3NE	27	8	6.5	7.0	0	3.37	1
6/10	4	4	3SW	7SW	23	9	6.0	7.0	.64	3.39	1
6/11	4	4	8SW				7.0		.46	3.40	1
6/12	4	4	Calm	3N	16	1	7.0	7.0	.23	3.43	1
6/13	3	1	10N	6N	20	5			0	3.38	1
6/14	1	3	8SW	3NE	24	5	8.0	8.0	0	3.43	1
6/15	3	2	3NE	3NW	24	2	8.0	9.0	0	3.44	1
6/16	2	3	3NE	Calm	24	4	8.5	9.0	0	3.44	1
6/17	3	4	3SW	10SW	22	2	8.0	8.0	0	3.43	1
6/18	4		7SW				8.0			3.44	1

[1] Depth of inshore half of center array.

Sky Codes:
1 - clear sky, cloud covering not more than 1/10 of sky.
2 - cloud covering not more than 1/2 of sky.
3 - cloud covering more than 1/2 of sky.
4 - complete overcast.
5 - fog.

Turbidity Codes:
1 - clear
2 - light turbidity

Table 2. Kvichak River sockeye salmon smolt counts by array less false counts, plus interpolation for missed time, 1980.

Date	Inshore	Center	Offshore	Total
5/15[1]	6,375	0	0	6,375
5/16	1,778	2,335	0	4,113
5/17	3,112	0	0	3,112
5/18	2,377	2,732	0	5,109
5/19	6,211	15,958	0	22,169
5/20	4,746	0	0	4,746
5/21	25,974	18,746	8,088	52,808
5/22	109,290	108,384	48,301	265,975
5/23	13,384	66,045	60,922	140,351
5/24	18,947	41,046	35,734	95,727
5/25	11,834	61,576	67,790	141,200
5/26	51,990	145,056	107,410	304,456
5/27	141,589	280,348	146,465	568,402
5/28	137,631	272,791	142,213	552,635
5/29	36,660	72,686	46,390	155,736
5/30	6,680	7,490	3,039	17,209
5/31	6,642	10,331	6,886	23,859
6/ 1	68,421	207,077	84,470	359,968
6/ 2	14,993	29,630	6,357	50,980
6/ 3	22,518	33,123	12,578	68,219
6/ 4	20,891	38,287	13,701	72,879
6/ 5	9,629	19,897	11,006	40,532
6/ 6	4,167	10,848	3,798	18,813
6/ 7	6,795	14,159	5,958	26,912
6/ 8	4,884	14,169	5,921	24,974
6/ 9	14,643	33,510	14,176	62,329
6/10	37,484	49,617	21,877	108,978
6/11	11,958	18,604	9,615	40,177
6/12	18,972	31,738	12,424	63,134
6/13	39,309	28,593	12,490	80,392
6/14	16,832	35,131	21,960	73,923
6/15	29,585	27,884	20,350	77,819
6/16	17,533	21,329	14,576	53,438
6/17	6,352	13,372	9,107	28,831
TOTAL	930,186	1,732,492	953,602	3,616,280
% OF TOTAL	0.2572	0.4791	0.2637	

[1] 12 hours only, from 0001 to 1200 on 16 May.

Table 3. Daily smolt outmigration estimate by age class with percent age composition and accumulated totals, Kvichak River, 1980.

DATE	AGE I	%	ACCUM.	AGE II	%	ACCUM.	TOTAL	ACCUM.
5/15	991,985	0.87	991,985	148,057	0.13	148,057	1,140,043	1,140,043
5/16	235,180	0.87	1,227,165	35,101	0.13	183,158	270,282	1,410,325
5/17	484,244	0.87	1,711,409	72,275	0.13	255,433	556,520	1,966,845
5/18	298,644	0.87	2,010,053	44,573	0.13	300,006	343,218	2,310,063
5/19	1,137,222	0.87	3,147,275	169,734	0.13	469,740	1,306,957	3,617,020
5/20	766,908	0.87	3,914,183	114,463	0.13	584,203	881,372	4,498,392
5/21	2,233,135	0.87	6,147,318	333,303	0.13	917,506	2,566,439	7,064,831
5/22	11,146,599	0.87	17,293,917	1,663,671	0.13	2,581,177	12,810,271	19,875,102
5/23	5,550,051	0.87	22,843,968	828,365	0.13	3,409,542	6,378,417	26,253,519
5/24	4,272,986	0.97	27,116,954	147,344	0.03	3,556,886	4,420,331	30,673,850
5/25	6,259,527	0.98	33,376,481	106,093	0.02	3,662,979	6,365,621	37,039,471
5/26	12,671,899	0.90	46,048,380	1,407,988	0.10	5,070,967	14,079,887	51,119,358
5/27	25,908,890	0.97	71,957,270	893,409	0.03	5,964,376	26,802,300	77,921,658
5/28	23,019,754	0.88	94,977,024	3,040,344	0.12	9,004,720	26,060,099	103,981,757
5/29	7,231,670	0.99	102,208,694	60,770	0.01	9,065,490	7,292,411	111,274,198
5/30	814,538	0.98	103,023,232	13,805	0.02	9,079,295	828,344	112,102,542
5/31	1,109,272	0.99	104,132,504	12,463	0.01	9,091,758	1,121,735	113,224,277
6/ 1	16,784,042	0.99	120,916,546	188,584	0.01	9,280,342	16,972,627	130,196,904
6/ 2	2,418,202	0.98	123,334,748	40,986	0.02	9,321,328	2,459,188	132,656,092
6/ 3	3,232,211	0.99	126,566,959	36,316	0.01	9,357,644	3,268,528	135,924,620
6/ 4	3,480,849	1.00	130,047,808	0	0.00	9,357,644	3,480,849	139,405,469
6/ 5	1,842,332	0.97	131,890,140	63,528	0.03	9,421,172	1,905,861	141,311,330
6/ 6	843,543	0.94	132,733,683	49,620	0.06	9,470,792	893,163	142,204,493
6/ 7	1,205,378	0.94	133,939,061	70,904	0.06	9,541,696	1,276,282	143,480,775
6/ 8	1,151,323	0.98	135,090,384	26,166	0.02	9,567,862	1,177,489	144,658,264
6/ 9	2,884,511	0.98	137,974,895	65,557	0.02	9,633,419	2,950,068	147,608,332
6/10	5,169,448	0.99	143,144,343	43,440	0.01	9,676,859	5,212,888	152,821,220
6/11	1,905,377	1.00	145,049,720	0	0.00	9,676,859	1,905,377	154,726,597
6/12	3,013,920	1.00	148,063,640	0	0.00	9,676,859	3,013,920	157,740,517
6/13	3,839,982	0.98	151,903,622	65,084	0.02	9,741,943	3,905,067	161,645,584
6/15	3,344,951	0.97	155,248,573	115,343	0.03	9,857,286	3,460,295	165,105,879
6/15	3,573,281	0.97	158,821,854	123,216	0.03	9,980,502	3,696,498	168,802,377
6/16	2,441,882	0.97	161,263,736	84,202	0.03	10,064,704	2,526,085	171,328,462
6/17	1,300,221	0.97	162,563,957	44,835	0.03	10,109,539	1,345,057	172,673,519

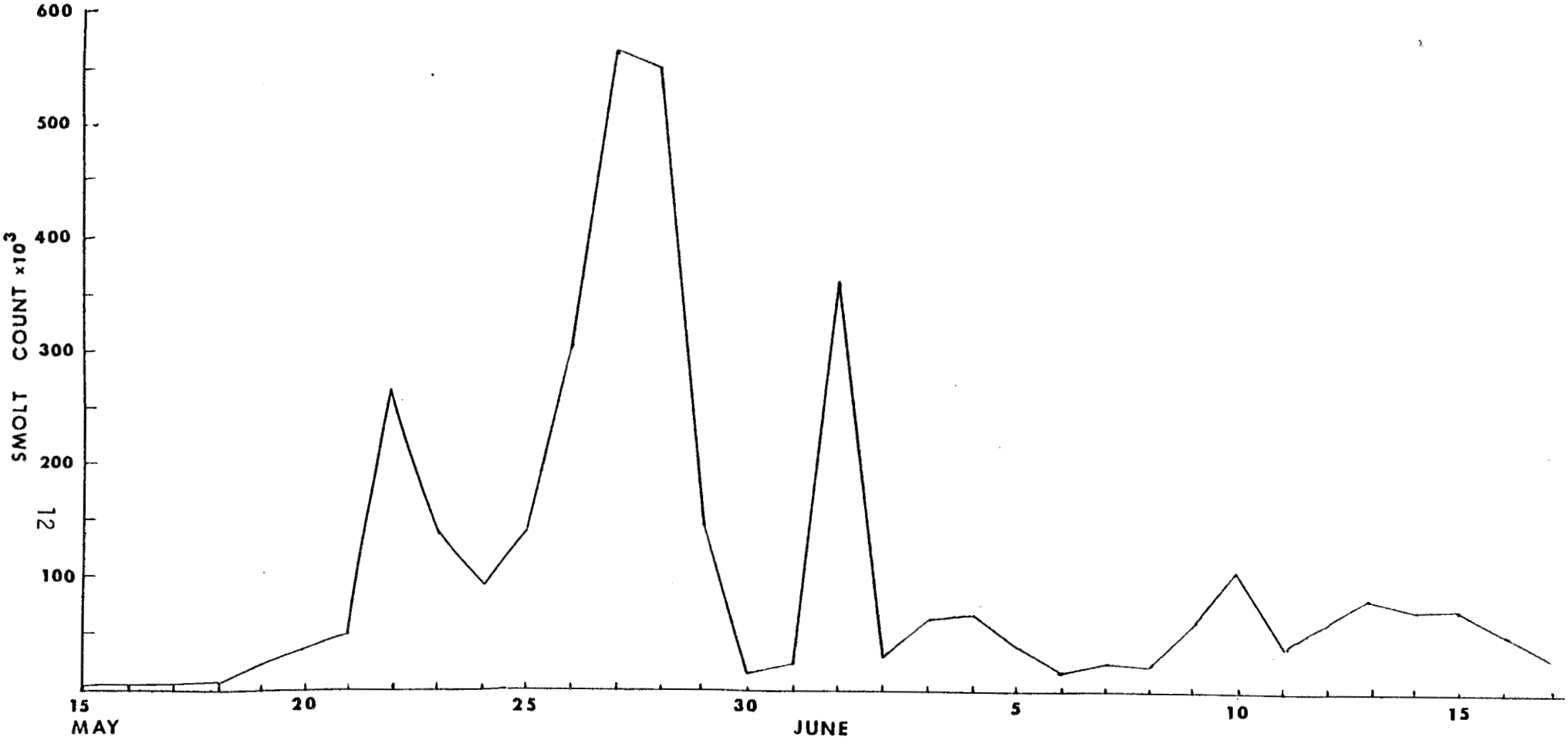

Figure 2. Total Kvichak River sockeye salmon smolt counts by day, less false counts, plus interpolation for missed time, 1980.

Table 4. Comparative Kvichak River sockeye salmon escapement, smolt production, age class composition, and smolt per spawner data[1].

Brood year	Escapement	Estimated Smolt Production				Age Proportion			Smolt per spawner
		Age I	Age II	Age III	Total	Age I	Age II	Age III	
1956	9,443,318					0.54	0.46	0.	
1957	2,842,810					0.13	0.87	0.	
1958	534,785					0.86	0.14	0.	
1959	680,000					0.27	0.73	0.	
1960	14,630,000					0.22	0.78	0.	
1961	3,705,849					0.07	0.93	0.	
1962	2,580,884					0.21	0.79	0.	
1963	338,760					0.73	0.27	0.	
1964	957,120					0.53	0.47	0.	
1965	24,325,926					0.34	0.66	0.	
1966	3,775,184					0.55	0.45	0.	
1967	3,216,208					0.67	0.33	0.	
1968	2,557,440		5,959,383	0		0.03	0.97	0.	
1969	8,394,204	85,723,430	67,004,325	0	152,727,756	0.56	0.44	0.	18.194
1970	13,935,306	570,750	189,138,158	4,925,610	194,634,518	0.00	0.97	0.03	13.967
1971	2,387,392	4,987,961	33,767,464	0	38,755,425	0.13	0.87	0.	16.233
1972	1,009,962	4,021,849	5,784,036	0	9,805,885	0.41	0.59	0.	9.709
1973	226,554	9,848,495	2,927,804	0	12,776,299	0.77	0.23	0.	56.394
1974	4,433,844	99,890,123	132,920,297	0	232,810,420	0.43	0.57	0.	52.508
1975	13,140,450	82,097,299	238,523,253	0	320,620,552	0.26	0.74	0.	24.400
1976	1,965,282	31,305,140	25,993,357	0	57,298,497	0.55	0.45	0.	29.155
1977	1,341,144	26,623,136	10,109,539		36,732,675	0.72	0.28		27.389
1978	4,149,288	162,563,957			162,563,958				39.179

[1] Estimated smolt production from total outmigration estimates using sonar enumeration. See Yuen (1979) for estimated smolt production using fyke net indices between 1956 and 1968.

Table 5. Kvichak River sockeye salmon escapement, smolt production, and adult returns (in millions of fish), and marine survival by brood year.

Brood year[1]	Escapement	Age I Smolt	2-freshwater Adult Return	Percent Survival	Age II Smolt	3-freshwater Adult Return	Percent Survival
1968[1]	2.56	-	-	-	5.96	.257	4.31
1969	8.39	85.72	.436	.51	67.00	4.738	7.07
1970	13.94	.57	.056	9.82	189.14	15.184	8.03
1971	2.39	4.99	.333	6.67	33.77	2.281	6.75
1972	1.01	4.02	.380	9.45	5.78	1.481	25.62
1973	.23	9.85	1.559	15.83	2.93	.772	26.35
1974	4.43	99.89	7.754	7.76	132.92	17.633	13.27
1975	13.14	82.10	6.875	8.37	238.52	28.533[2]	11.96[2]
1976	1.97	31.31	5.057[3]	16.15[3]	25.99		
1977	1.34	26.62			10.11		

[1] Incomplete data.

[2] Ages 4_3 and 5_3 only.

[3] Ages 3_2 and 4_2 only.

Table 6. Mean length (mm), mean weight (g), variance (s^2), and sample size (n) for sockeye salmon smolt by age class and sample date, Kvichak River, 1980.

	AGE I					AGE II				
Date	Mean Length	Var.	Mean Weight	s^2	n	Mean Length	s^2	Mean Weight	s^2	n
5/22	82.00	56.50	4.98	1.82	5					
5/23	88.68	9.85	5.93	.47	129	114.90	36.73	12.12	2.63	20
5/24	88.26	10.55	5.70	.49	87	109.33	10.33	10.03	1.21	3
5/25	88.81	9.37	5.95	.71	118	106.00	50.00	9.85	3.13	2
5/26	90.10	13.08	6.08	.56	108	106.92	72.81	9.91	6.16	12
5/27	88.95	10.54	5.96	.48	116	105.25	64.92	9.70	3.95	4
5/28	89.46	8.08	5.97	.45	106	109.21	50.34	10.54	2.85	14
5/29	89.37	12.76	6.00	.87	119	103.00		9.1		1
5/30	87.61	8.31	5.81	.38	59	115.00		10.5		1
5/31	86.31	9.99	5.55	.47	89	89.00		6.1		1
6/01	86.17	9.23	5.45	.43	89	111.00		11.2		1
6/02	85.85	5.03	5.56	.29	59	109.00		8.4		1
6/03	86.42	13.34	5.56	.48	89	118.00		12.6		1
6/04	87.89	11.56	5.84	.56	90					
6/05	89.19	9.52	6.03	.47	58	96.50	24.50	7.55	1.80	2
6/06	88.55	18.21	6.23	.84	53	109.50	.50	11.15	.84	2
6/07	88.69	8.38	6.05	.50	49	109.75	40.92	10.95	3.14	4
6/08	85.87	8.40	5.52	.37	30					
6/09	88.47	9.48	5.94	.40	58	114.0	72.00	11.0	5.12	2
6/10	88.46	11.91	6.03	.48	119	109.0		10.0		1
6/11	88.39	21.45	6.19	1.13	59					
6/12	87.21	15.52	5.69	.65	90					
6/13	91.75	13.78	6.89	.73	59	108.0		10.3		1
6/14	91.64	19.78	6.58	.75	58	116.5	6.25	10.8	.49	2

LITERATURE CITED

Krasnowski, Paul. 1975. 1974 Kvichak River sockeye salmon smolt studies. In 1974 Bristol Bay sockeye salmon smolt studies. (Ed. P. Krasnowski). Alaska Department of Fish and Game Technical Report No. 20, pp. 1-13.

Parker, Kenneth P. 1974a. 1972 Kvichak River sockeye salmon smolt studies. In 1972 Bristol Bay sockeye salmon smolt studies. (Ed. Kenneth P. Parker). Alaska Department of Fish and Game Technical Data Report No. 13, pp. 1-37.

Parker, Kenneth P. 1974b. 1973 Kvichak River sockeye salmon smolt studies. In 1973 Bristol Bay sockeye salmon smolt studies. (Ed. Kenneth P. Parker). Alaska Department of Fish and Game Technical Data Report No. 14, pp. 1-22.

Paulus, Robert D. and Michael L. McCurdy. 1972. 1970 Kvichak River sockeye salmon smolt studies. In 1970 Bristol Bay sockeye salmon smolt studies. (Ed. Phillip Russell). Alaska Department of Fish and Game Technical Data Report No. 4, pp. 1-13.

Randall, Richard C. 1977. 1976 Kvichak River sockeye salmon smolt studies. In 1976 Bristol Bay sockeye salmon smolt studies. (Ed. N. Newcome). Alaska Department of Fish and Game Technical Data Report No. 33, pp. 1-13.

Russell, Phillip A. 1972. 1971 Kvichak River sockeye salmon smolt studies. In 1971 Bristol Bay sockeye salmon smolt studies. (Ed. P. Russell and M. McCurdy). Alaska Department of Fish and Game Technical Data Report No. 2, pp. 1-28.

Snedecor, G. W. and W. G. Cochran. 1967. Statistical Methods. 592 pp. Iowa State University Press. Ames, Iowa.

Yuen, Henry J. 1980. 1979 Kvichak River smolt studies. In 1979 Bristol Bay sockeye salmon smolt studies. (Ed. Charles P. Meacham). Alaska Department of Fish and Game Technical Data Report No. 46, pp. 1-11.

Appendix Table 1. Water temperatures (°C) during smolt studies, Kvichak River, 1963 to 1980.

Year	Start	End	Minimum	Maximum	Mean
1963	5/16	6/14	2.22	8.89	5.5
1964	5/18	6/14	0.00	5.6	2.6
1965	5/17	6/11	0.00	8.9	4.4
1966	5/16	6/26	0.00	11.1	4.7
1967	5/17	6/20	1.1	9.4	6.9
1968	5/12	6/12	3.3	8.3	5.4
1969	5/16	6/18	0.3	7.8	3.9
1970	5/13	6/07	2.8	11.1	6.8
1971	5/17	6/20	1.1	3.3	2.4
1972	5/18	6/18	0.6	5.0	2.9
1973	5/15	6/14	2.9	8.9	4.9
1974	5/13	6/09	3.0	8.0	6.2
1975	5/17	6/15	2.0	8.0	3.8
1976	5/18	6/19	2.0	9.5	3.9
1977	5/17	6/14	3.0	9.5	6.4
1978	5/19	6/09	5.0	11.0	7.6
1979	6/01	6/10	8.0	10.0	8.6
1980	5/16	6/18	1.5	9.0	5.5
Mean					$\bar{x}$ 5.13

Appendix Table 2. Comparative age, length, weight, and outmigration estimate of sockeye salmon smolt from the Kvichak River.

Year of seaward migration	AGE I			AGE II			AGE III			Out-migration estimate[1]
	%	Length (mm)	Wt. (g)	%	Length (mm)	Wt. (g)	%	Length (mm)	Wt. (g)	
1955	0.07	89.0	0.	0.93	0.	0.	0.	0.	0.	260,068
1956	0.39	92.0	0.	0.61	116.0	0.	0.	0.	0.	77,660
1957	0.72	96.0	7.3	0.28	120.0	14.0	0.	0.	0.	30,907
1958	0.98	84.0	4.6	0.02	114.0	0.	0.	0.	0.	3,333,953
1959	0.03	80.0	0.	0.97	99.0	7.6	0.	0.	0.	2,863,876
1960	0.10	91.0	6.3	0.90	108.0	10.3	0.	0.	0.	614,003
1961	0.72	92.0	6.8	0.28	117.0	13.1	0.	0.	0.	36,164
1962	0.94	82.0	4.3	0.06	110.0	9.9	0.	0.	0.	1,203,000
1963	0.03	83.0	4.8	0.97	98.0	7.5	0.	0.	0.	4,229,431
1964	0.22	87.0	5.2	0.78	108.0	9.8	0.	0.	0.	2,061,586
1965	0.04	90.0	6.8	0.96	109.0	11.3	0.	0.	0.	1,812,555
1966	0.92	94.0	7.4	0.08	114.0	12.6	0.	0.	0.	275,761
1967	0.93	86.0	5.9	0.07	118.0	14.2	0.	0.	0.	3,088,742
1968	0.11	88.0	5.5	0.89	104.0	9.2	0.	0.	0.	6,123,683
1969	0.52	92.5	5.7	0.48	109.3	10.6	0.	0.	0.	1,135,344
1970	0.38	90.8	6.0	0.62	110.2	11.0	0.	0.	0.	483,638
1971	0.94	89.9	5.8	0.07	111.0	11.1	0.	0.	0.	91,682,813
1972	0.01	80.0	4.2	0.99	106.0	10.0	0.	0.	0.	67,575,075
1973	0.03	85.6	5.1	0.97	97.1	8.3	0.	0.	0.	194,126,120
1974	0.09	95.5	8.3	0.79	111.0	13.1	0.12	123.5	17.5	42,714,923
1975	0.63	97.7	8.4	0.37	121.9	16.4	0.	0.	0.	15,632,531
1976	0.97	88.2	5.8	0.03	120.8	14.2	0.	0.	0.	102,817,927
1977	0.38	86.0	5.5	0.62	106.0	10.1	0.	0.	0.	215,017,596
1978	0.12	88.1	6.0	0.88	96.9	7.8	0.	0.	0.	269,828,392
1979	0.51	89.6	6.0	0.49	108.9	10.3	0.	0.	0.	52,616,493
1980	0.94	88.4	5.9	0.06	109.9	10.7	0.	0.	0.	172,673,496

[1] Fyke net indices from 1955 through 1970; near estimates of total smolt outmigration 1971 through 1980.

1980 WOOD RIVER SOCKEYE SALMON SMOLT STUDIES

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INTRODUCTION

Annual sockeye *(Oncorhynchus nerka)* smolt migrations out of the Wood River Lakes system range between 20 and 100 million fish over about a 90-day period (approximately 1 June - 30 August) each summer. Reliable estimates of the numbers of smolts leaving the system are required for forecasting future adult returns and studying optimum escapement to the spawning grounds. Annual outmigration estimates combined with data on smolt age composition and mean length and weight provide a means for evaluating smolt predation and lake fertilization studies also being conducted in the Wood River system.

A program to enumerate smolt by sonar was initiated in 1975 because various index programs operated prior to that time proved to be of limited value in forecasting future runs. The sonar project has continued through 1980 with the following objectives: (1) estimating numbers of outmigrating smolt; (2) determining the qualitative aspects of the smolt run (age composition, mean length, weight, incidence of the parasite *Triaenophorus crassus*); and (3) calibrating the sonar counter to test the accuracy of the hydroacoustic counts.

METHODS AND MATERIALS

Sonar Arrays

The same four transducer arrays and electronic control unit used since 1976 (Krasnowski 1976, 1977) were used again in 1980. The system consists of 40 transducers mounted in four ladder-like arrays, each monitored separately on the river bottom. The 10 transducer cables from each array are taped together and the entire bundle is secured to the river bank with a safety line. The four cable bundles are connected to the electronic counting unit which is powered by a 12-volt battery. The counter is kept in a wall tent where technicians control and monitor the system. Placement of the gear has been in the same location in the river each year since 1975.

Installation and operation of the gear was similar to methods used in 1979 (Bucher 1980). The arrays were originally positioned in the river so that distances from the north bank of Arrays I, II, III, and IV were: 20.4, 34.1, 46.6, and 70.7 m, respectively. After the underwater gear was damaged by a submerged boat on 6/18, Arrays III and IV were brought to the surface for repairs and were later repositioned so that Array III was 55.7 m and Array IV was still 70.7 m from the north bank.

The arrays were installed in the river on 1 June and the counter was operated from 2100 until 0300 that night. The daily random counting schedule was begun on 2 June and continued through 0600 on 16 August. The sampling design and sonar data collection procedures were consistent with those used in 1979 (Bucher 1980). The sonar gear was operated 75 hours (25 randomly selected 3-hour blocks) per 5-day sample period. Array III was designated as the index array and operated during all sampling hours. The other three arrays were operated in a random sequence for 15-minute intervals within each hour, and these 15-minute counts were expanded to yield hourly counts for each array.

Adjustment of Sonar Counts

The sonar counter was operated at one velocity setting (4.5 fps) all season. During periods of tidal influence, velocity factors were applied to the raw sonar counts to yield corrected counts (Bucher 1980). Appendix Table 1 provides a summary of velocity data used to adjust the counts throughout the season. Adjusted counts were then expanded for the entire width of the river by expansion factors which were assigned to each array. The expansion factors were a function of distance between the individual arrays. When the arrays were moved in-season for repairs, the expansion factors were recalculated. Initial expansion factors were Array I - 5.35, Array II - 3.92, Array III - 5.46, and Array IV - 6.02. These were later changed as follows: Array I - 5.53, Array II - 5.10, Array III - 5.28, and Array IV - 5.66.

Because the sonar system was not monitored 24-hours per day, counts were estimated by linear interpolation for those time periods not sampled. After interpolation, counts were summed to yield a daily total expanded count. Since the sonar system is a biomass counter designed to register one count for the biomass equivalent of five smolt, the daily total expanded count was multiplied by five to estimate the actual daily smolt count.

Sonar Calibration Tests

Several tests were made during July in an attempt to determine if the sonar system was, in fact, counting at the designed rate (one count per five smolt). Catches from a fyke net, anchored immediately behind Array I, were compared with the sonar counts for given periods of time. Similar calibration work was performed by Clark and Robertson (1980) which indicated that the sonar unit was essentially counting at the proper rate. This season, several modifications and improvements to the fyke net technique were made.

The tests were conducted with a large fyke net that sampled all but the deepest portion of the water column which was insonified or sampled by sonar. Due to the water depth, that portion of the water column immediately above the sonar array (about 1 m) was not sampled by the fyke net. However, it was determined by visual observation of the oscilloscope that few, if any, smolt occur at that depth in the river.

Absence of floatation devices such as styrofoam collars used by Clark and Robertson (1980) reduced much of the backwash previously noted. The tests

were conducted during periods when weather conditions (wind and rain) would not influence the counts and when adequate numbers of smolt were emigrating.

Age-Weight-Length Sampling

Smolt samples were collected for age-weight-length analysis during each 5-day sampling period. During most of June, samples were obtained by beach seine near the outlet of Lake Aleknagik. However, the preferred method for collecting samples is by fyke net in the Wood River (Bucher 1980). This method, established in late June after high water conditions began to subside was used for the remainder of the project.

Sampling goals were set at 300 smolt per 5-day period or 60 fish per day. A fork length measurement and scale samples were taken from each smolt. Weights were measured from at least 12 smolt per day and all smolt were externally examined for presence of the parasite *Triaenophorus crassus*.

RESULTS

Climatological and Hydrological Observations

Daily water temperatures and lake level measurements recorded at the sonar site during the smolt outmigration are presented in Table 1. Maximum and minimum seasonal water temperatures were 17.8° C (26 July) and 4.4° C (30 May), respectively. Mean lake depth recorded at the ADF&G camp was 1.07 m (3.50 ft). A comparison of water temperatures and mean lake depth measurements for the years 1975-1980 is presented in Appendix Table 2.

Outmigration Estimates

The sonar counter was operated for 15 five-day periods for a total of 75 days. A total of 1,814,000 raw counts was enumerated. Of this total, 34% were recorded by Array I, 35% by Array II, 21% by Array III, and 10% by Array IV. This seasonal distribution of smolt across the river is shown relative to the past 5 years in Appendix Table 3. Expansion of the raw counts yielded an estimated total outmigration of 48,295,932 smolt. Table 2 lists the estimated smolt outmigration by age class and sample period. The estimated daily total outmigration is illustrated in Figure 1.

Age-Weight-Length

A total of 3,916 smolt was measured to determine mean length and age. Age composition estimates and mean lengths by sample period derived from beach seine and fyke net sampling are given in Table 3. Mean lengths for the season of Age I and Age II smolt were 77.8 mm and 94.6 mm, respectively. Age I smolt comprised 96% of the outmigration; Age II smolt comprised 4%, the majority of which emigrated during June and early July. A comparison of the mean length of smolt by year and age class for the years 1951-1980 is presented in Table 4. Mean weights for the 1980 season are presented by sample period in Table 5. Mean weight of Age I smolt was 4.0 g while that of Age II smolt

Table 1. Water temperatures and lake depths recorded at ADF&G cabin, Wood River, 1980.

Date	Surface Temperature (°C)	Lake Depth (Ft.)	Date	Surface Temperature (°C)	Lake Depth (Ft.)
5/30	4.4	5.2			
5/31	4.4	5.2			
6/ 1	5.5	5.2			
6/ 2	4.4	5.3	7/12	8.9	3.58
6/ 3	4.4	5.3	7/13	9.7	3.55
6/ 4	4.4	5.4	7/14	8.9	3.55
6/ 5	4.4	5.4	7/15	11.1	3.50
6/ 6	5.5	(Over gauge)	7/16	10.3	3.50
6/ 7	5.5	"	7/17	12.8	3.45
6/ 8	5.5	5.4	7/18	10.0	3.25
6/ 9	5.0	5.4	7/19	12.8	3.14
6/10	5.5	5.4	7/20	15.0	2.99
6/11	5.5	5.3	7/21	14.7	2.91
6/12	5.5	5.3	7/22	15.3	2.80
6/13	5.5	5.2	7/23	16.1	2.66
6/14	5.5	5.1	7/24	16.7	2.60
6/15	6.6	5.1	7/25	17.2	2.46
6/16	6.1	4.85	7/26	17.8	2.35
6/17	6.1	4.75	7/27	16.1	2.22
6/18	6.6	4.63	7/28	15.6	2.17
6/19	6.1	4.47	7/29	15.3	2.08
6/20	5.8	4.50	7/30	15.0	2.08
6/21	5.8	4.28	7/31	15.6	2.02
6/22	5.3	4.10	8/ 1	16.1	1.88
6/23	5.0	4.05	8/ 2	13.9	1.98
6/24	5.0	3.98	8/ 3	14.4	1.90
6/25	5.5	3.96	8/ 4	13.9	1.86
6/26	6.1	3.90	8/ 5	14.4	1.74
6/27	6.9	3.80	8/ 6	11.1	1.76
6/28	7.8	3.71	8/ 7	10.0	1.56
6/29	8.9	3.62	8/ 8	10.0	1.44
6/30	8.9	3.54	8/ 9	11.1	1.34
7/ 1	7.2	3.42	8/10	11.1	1.20
7/ 2	7.8	3.48	8/11	11.1	1.15
7/ 3	-	-	8/12	9.4	1.10
7/ 4	-	-	8/13	-	(Below gauge)
7/ 5	7.2	3.50	8/14	11.1	(Below gauge)
7/ 6	8.9	3.52	8/15	10.6	(Below gauge)
7/ 7	7.8	3.58			
7/ 8	7.2	3.52			
7/ 9	6.7	3.48			
7/10	7.8	3.42			
7/11	8.9	3.48			

Table 2. Estimated smolt outmigration by age class and sample period, Wood River, 1980.

Sample Period	n	Age I No.	Age I %	Age II No.	Age II %	Total
June 2- 6	289	699,440	94	44,645	6	744,085
June 7-11	278	445,928	99	4,504	1	450,432
June 12-16	238	531,707	99	5,371	1	537,078
June 17-21	294	122,718	89	11,167	11	137,885
June 22-26	298	1,046,724	84	199,376	16	1,246,100
June 27-July 1	300	1,601,288	92	139,242	8	1,740,530
July 2- 6	300	6,151,700	90	683,522	10	6,835,222
July 7-11	300	8,750,210	97	270,625	3	9,020,835
July 12-16	300	9,535,629	97	294,916	3	9,830,545
July 17-21	300	5,806,351	99	58,650	1	5,865,001
July 22-26	300	4,349,739	98	88,770	2	4,438,509
July 27-31	216	2,599,182	97	80,387	3	2,679,569
August 1- 5	177	2,418,143	98	49,350	2	2,467,493
August 6-10	126	1,005,602	98	20,522	2	1,026,124
August 11-15	195	1,238,228	97	38,296	3	1,276,524
Total[1]	3,911	46,302,587	96	1,993,345	4	48,295,932

[1] Age composition of the total outmigration weighted by outmigration estimate for each sample period.

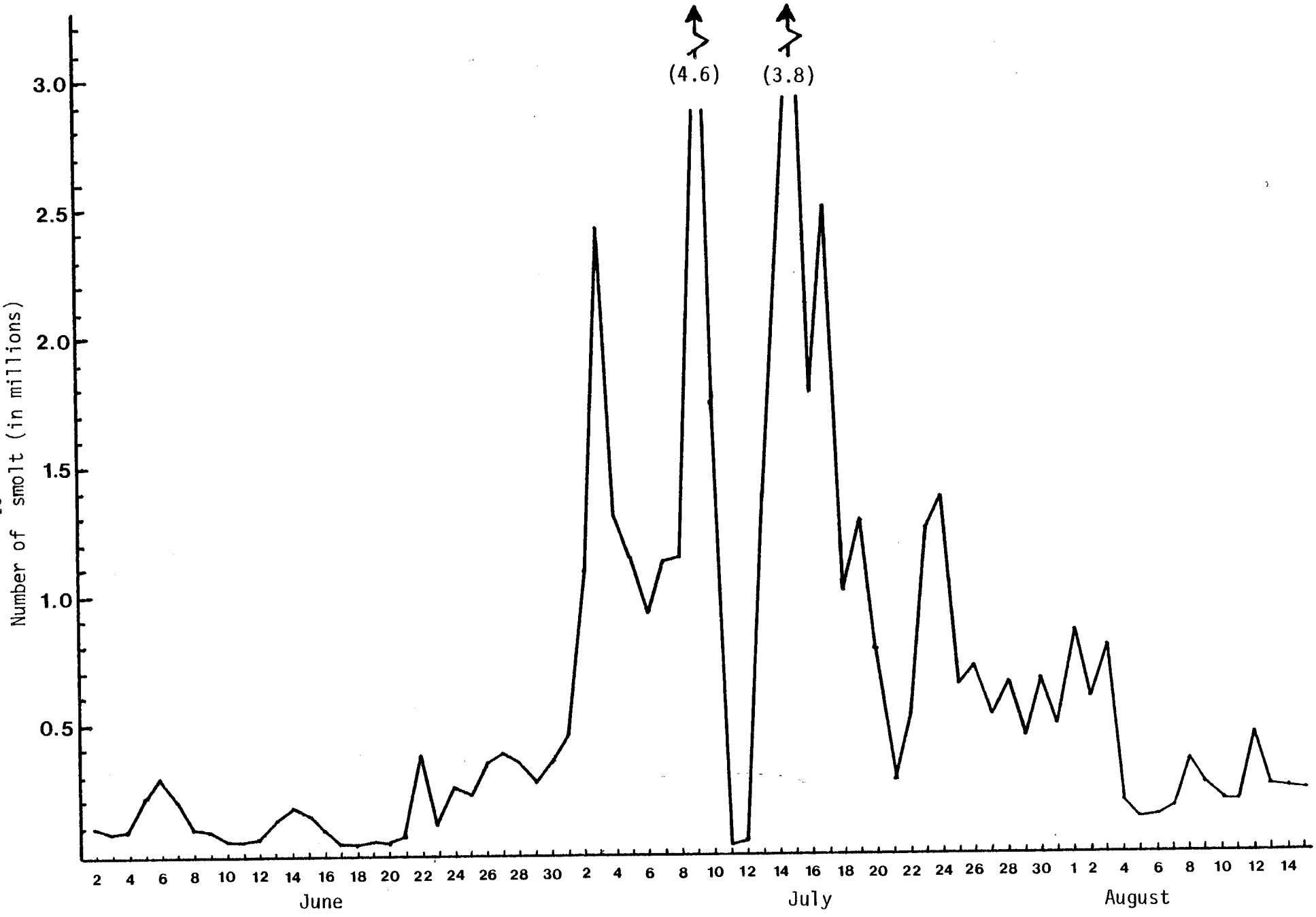

Figure 1. Estimated daily total outmigration of sockeye salmon smolt, Wood River, 1980.

Table 3. Sample sizes (n), mean length (mm), and variances (s^2) for Age I and Age II sockeye salmon smolt, by sample period, Wood River, 1980.

	Age I			Age II		
Sample Period	n	Mean Length	s^2	n	Mean Length	s^2
June 2- 6	271	72.0	67.66	18	91.4	80.00
June 7-11	275	66.3	60.42	3	92.3	14.20
June 12-16	238	68.9	67.52	2	88.0	144.00
June 17-21	264	68.3	82.48	30	90.1	65.27
June 22-26	252	77.8	60.97	46	91.3	58.51
June 27-July 1	275	78.4	55.21	26	96.9	104.75
July 2- 6	271	82.0	45.64	29	103.8	99.52
July 7-11	291	74.1	70.16	9	85.9	24.32
July 12-16	291	76.8	23.77	9	89.3	75.56
July 17-21	296	75.7	23.03	4	84.8	4.69
July 22-26	294	78.7	22.01	6	87.5	62.92
July 27-31	210	79.5	16.81	6	94.5	26.58
August 1- 5	177	82.8	14.89	3	93.0	24.00
August 6-10	124	86.6	18.72	2	92.5	12.25
August 11-15	190	88.4	12.18	5	91.2	31.36
June 2 - August 15[1]	3,719	77.8		197	94.6	

[1] Mean length for the entire season was derived by weighting the mean length for each sample period by the total outmigration estimate for that period (Table 3).

Table 4. Mean length of sockeye salmon smolt by year and age class, Wood River, 1951-1980[1].

Year of Seaward Migration	Age I		Age II	
	Percent	Mean Length in mm	Percent	Mean Length in mm
1951	80.0	91.0	20.0	-
1952	99.0	87.0	1.0	-
1953	95.3	86.0	4.7	103.0
1954	95.8	87.0	4.2	107.0
1955	98.0	85.0	2.0	102.0
1956	78.4	82.0	21.6	95.0
1957	80.7	77.0	19.3	93.0
1958	65.0	82.0	35.0	102.0
1959	93.5	87.9	6.5	105.0
1960	99.4	88.0	0.6	114.0
1961	93.0	81.7	7.0	102.1
1962	86.0	80.1	14.0	97.6
1963	84.3	82.6	15.7	102.1
1964	98.8	83.7	1.2	104.2
1965	92.0	85.5	8.0	106.1
1966	94.3	77.1	5.7	101.2
1967-1974[2]	-	-	-	-
1975	(86.0)[3]	82.5	(14.0)[3]	97.9
1976	95.5	83.5	4.5	94.9
1977	82.9	70.5	17.1	98.1
1978	84.7	79.4	15.3	89.7
1979	92.2	89.7	7.8	99.8
1980	96.0	77.8	4.0	94.6
1951-80 Average	89.6	83.0	10.4	100.5
1951-66 Average	89.6	84.0	10.4	102.5
1975-80 Average	89.6	80.6	10.4	95.8

[1] 1951-1974 Data Source: ADF&G Bristol Bay Annual Management Report, 1974. Age and length weighted by estimated outmigration for a given sample period based on a fyke net index program.

[2] Program not in operation or incomplete data.

[3] Percentage not weighted by estimated outmigration by period.

Table 5. Sample size (n), mean weight in grams, and variance (s^2) on Age I and Age II sockeye salmon smolt, by sample period, Wood River, 1980.

Sample Period	Age I			Age II		
	n	Mean Weight	s^2	n	Mean Weight	s^2
June 2- 6	112	3.5	1.17	10	6.2	2.21
June 7-11	59	2.7	.63	0	-	-
June 12-16	46	2.5	.78	2	5.8	2.40
June 17-21	58	2.7	1.24	3	4.1	.65
June 22-26	48	3.8	.82	12	5.4	1.57
June 27-July 1	56	4.3	1.73	4	6.8	4.37
July 2- 6	53	4.3	.97	7	8.8	2.53
July 7-11	56	3.4	1.47	4	5.1	.22
July 12-16	56	3.7	.76	4	6.3	5.24
July 17-21	57	3.6	.48	3	4.8	.13
July 22-26	59	4.2	.92	1	6.5	-
July 27-31	59	4.3	.48	1	7.5	-
August 1- 5	35	4.9	.39	1	5.7	-
August 6-10	46	5.8	.63	0	-	-
August 11-15	44	6.7	.61	3	6.3	.19
June 2 - August 15[1]	844	4.0		55	6.8	

[1] Mean weight for the entire season was derived by weighting the mean weight for each sample period by the total outmigration estimate for that period (Table 3).

was 6.8 g. Age composition and mean weight and length of the total outmigration was weighted by the outmigration estimate for each sample period.

Table 6 lists the estimated percentage of sockeye smolt infected by the cestode *Triaenophorus crassus*. Overall, 11.1% of the Age I smolt and 17.3% of the Age II smolt were estimated to be infected by the parasite.

Sonar Calibration Tests

A summary of sonar counts vs fyke net catches for three separate calibration tests during July is provided in Appendix Table 4. One of those tests was influenced by rain. In the other two tests the number of smolt per sonar count ranged from 0 to 4.49, with a mean of 2.32. The smolt per count data indicates that the sonar gear was not counting at the designed rate of five smolt per count. However, it was determined that the test data did not provide sufficient accuracy to warrant adjusting the hydroacoustic counts by a factor other than five. Test data did show that serious deficiencies exist in fyke net design and application which preclude an accurate calibration of the sonar equipment by this method (see Discussion below).

DISCUSSION

Smolt Production

The 1980 outmigration of Age II smolt (1.99 million) combined with the 1979 Age I outmigrants (60.84 million), equals a total of 62.83 million smolt produces from the 1977 escapement into the Wood River system. A summary of smolt outmigration estimates by age class for 1975-1980 is given in Table 7. These data are shown relative to brood year escapements in Table 8.

Smolt production from the 1977 escapement of 560,000 was calculated to be 112.19 smolt per spawner, the highest recorded since the initiation of sonar sampling in the Wood River. It is interesting that the exceptionally low 1973 escapement of 330,000 produced the next highest smolt per spawner ratio of 99.24. In contrast, the 1978 escapement of 2.27 million produced only 46.30 million Age I smolt this season. Age II smolt from the large 1978 escapement must be enumerated in 1981 before the smolt production per spawner can be calculated.

Marine Survival

Survival of smolt enumerated from the Wood River sonar site in 1975 and 1976 has been calculated using the two and three-ocean adult returns, since these age classes comprise virtually 100% of the Wood River run (Table 9). Marine survival for the 1973 and 1974 brood years was calculated to be 4.30% and 4.32%, respectively. The three-ocean fish from the 1975 escapement returned in 1980 for a combined adult return of 3.806 million from that brood year. The 1975 escapement of 1.27 million produced an estimated 69.15 million smolt. Marine survival of these smolt can then be calculated to be at least 5.50% and perhaps higher if a significant number of four-ocean adults return in 1981.

Table 6. Samples sizes and estimated infection by the cestode *Triaenophorus crassus* of Age I and Age II sockeye salmon smolt by sample period, Wood River, 1980.

Sample Period	Age I		Age II	
	n	% T.C.	n	% T.C.
June 2- 6	271	26.9	18	38.9
June 7-11	275	23.3	3	33.3
June 12-16	238	26.5	2	50.0
June 17-21	264	19.7	30	6.7
June 22-26	252	8.3	46	13.0
June 27-July 1	275	9.5	25	16.0
July 2- 6	271	15.5	29	17.2
July 7-11	291	13.4	9	11.1
July 12-16	291	11.7	9	0.0
July 17-21	296	8.8	4	0.0
July 22-26	294	7.5	6	33.3
July 27-31	210	6.7	6	0.0
August 1- 5	177	8.5	3	0.0
August 6-10	124	4.8	2	0.0
August 11-15	190	3.7	5	20.0
June 2 - August 15[1]	3,719	11.1	197	17.3

[1] The overall percentage of smolt infected by the parasite *T. crassus* was derived by weighting the percentage of infection in each sample period by the total outmigration estimate for that period (Table 3). Infection was only determined by gross external observations.

Table 7. Summary of smolt outmigration by year and age class, Wood River, 1975-1980, in millions of smolt[1].

Year of Outmigration	Age I	Age II	Total
1975	27.95	5.90	33.85
1976	101.40	4.80	106.20
1977	60.75	12.55	73.30
1978	46.60	8.40	55.00
1979	60.84	5.13	65.97
1980	46.30	1.99	48.29

[1] Totally expanded sonar counts, derived by expansion factor of (5) smolt per count.

Table 8. Summary of smolt outmigration by brood year escapements, by age class, in millions of smolt and smolt production per spawner, Wood River, 1972-1978.

Brood Year	Escapement	Age I	Age II	Total	Smolt Production Per Spawner
1972	0.43	-	5.90	-	-
1973	0.33	27.95	4.80	32.75	99.24
1974	1.71	101.40	12.55	113.95	66.64
1975	1.27	60.75	8.40	69.15	54.45
1976	0.82	46.60	5.13	51.73	63.09
1977	0.56	60.84	1.99	62.83	112.19
1978	2.27	46.30	-	-	-

Table 9. Wood River sockeye salmon escapement, smolt production and adult returns (in millions of fish) and marine survival by brood years.

Brood Year	Escapement	Age I Smolt	2-freshwater Adult Return[2]	Percent Survival	Age II Smolt	3-freshwater Adult Return[2]	Percent Survival
1972[1]	0.43	-	1.352	-	5.90	.066	1.12
1973	0.33	27.95	1.342	4.80	4.80	.099	2.06
1974	1.71	101.40	4.514	4.45	12.55	.455	3.63
1975	1.27	60.75	3.454	5.69	8.40	.378[3]	4.50[3]
1976	0.82	46.60	2.146[4]	4.61[4]	5.13	-	-
1977	0.56	60.84	-	-	1.99	-	-
1978	2.27	46.30	-	-	-	-	-

[1] Incomplete data.

[2] Figures reflect slight differences from those published in Bucher (1980) due to more complete data on adult returns.

[3] 5_3 only.

[4] 3_2 and 4_2 only.

Sonar Calibration

Several problems during the tests were identified as a function of the actual fyke net design. In order to cover the entire width of the sonar array, it was necessary to spread the wings of the net to cover approximately 3.3 m. This allowed the net to fish at an angle more perpendicular to the river's current. As a result of the net's orientation, smolt were gilled in the web.

Size of the mesh was also a critical factor. Not only was the mesh large enough to gill smolt, but some smaller fish were actually observed passing through the mesh, although the number appeared to be minimal. As an alternative, smaller mesh would prevent gilling of the smolt, but the advantage would be outweighed by the significant "backwash" created in front of the net which causes some smolt to completely avoid the net. In addition, the smaller mesh nets are extremely difficult to handle in fast current.

Another major difficulty involved the large number of smolts that had to be hand-counted after being captured in the fyke net. According to Bendix engineer Albert Menin (personal communications), highest precision is obtained from the sonar at maximum smolt passage rates. Thus, counting individual fish is nearly impossible at the passage rates required for the desired precision of the test. Any technique for estimating fyke net catches by subsampling was dismissed as being too inaccurate for calibration purposes.

Before the fyke net calibration technique may be employed, at least three basic assumptions are required:

(1) Smolt do not see (or sense) the fyke net, which would cause them to pass back over the array and thus be counted more than once.

(2) All smolt that pass over the array are eventually captured in the live box and tallied by hand. This implies that smolt do not escape, either by passing through the web, becoming gilled in the web, or avoiding the net entirely.

(3) The column of water sampled by the fyke net corresponds to the same area hydroacoustically sampled by sonar.

From our tests this summer it was determined that the above assumptions did not hold true. Therefore, it was concluded that fyke netting as accomplished this season is not a viable method of calibrating the sonar counts, and other means must be investigated.

LITERATURE CITED

Bucher, W.A. 1980. 1979 Wood River sockeye salmon smolt studies. In 1979 Bristol Bay sockeye salmon smolt studies. (Ed. C.P. Meacham). Alaska Department of Fish and Game, Technical Data Report No. 46, pp. 12-33.

Clark, J.H. and T.L. Robertson. 1980. 1978 Wood River sockeye salmon smolt studies. In 1978 Bristol Bay sockeye salmon smolt studies. (Ed. C.P. Meacham). Alaska Department of Fish and Game, Technical Data Report No. 44, pp. 18-29.

Krasnowski, P. 1976. 1975 Wood River sockeye salmon smolt studies. (Ed. P. Krasnowski). Alaska Department of Fish and Game, Technical Data Report No. 25, pp. 29-51.

_____. 1977. 1976 Wood River sockeye salmon smolt studies. In 1976 Bristol Bay sockeye salmon smolt studies. (Ed. N. Newcome). Alaska Department of Fish and Game, Technical Data Report No. 33, pp. 24-43.

Appendix Table 1. Standard velocity factors by sample period and array ratio factors by sample period and array, Wood River sonar site, Alaska, 1980.

Sample Period	Standard Velocity Factor	Array Ratio Factor		
		I	II	IV
1	1.43	.96	.98	.98
2	1.41	.90	.98	1.02
3	1.41	.93	1.00	1.01
4	1.33	.89	.98	1.00
5	1.32	.89	.95	.97
6	1.27	.86	.95	1.00
7	1.26	.90	.97	1.01
8	1.24	.89	.95	.98
9	1.25	.86	.93	1.03
10	1.22	.90	.97	1.01
11	1.15	.89	.98	.99
12	1.09	.88	.98	.92
13	1.03	.86	.95	1.02
14	1.03	.81	.94	1.05

Appendix Table 2. Mean water temperature and lake depth, Wood River sonar site, 1975-1980.

Year	Project Dates	Temperature (°C)			Depth (m)	
		Minimum	Maximum	Mean	Mean	Range
1975	5/29 - 7/19	2.0	9.5	5.0	0.368	.567 - (-) .238
1976	6/ 9 - 8/ 7	2.0	14.0	8.0	0.570	1.067 - .244
1977	6/ 9 - 8/ 8	4.5	15.5	9.0	1.521	-
1978	5/28 - 8/ 9	5.0	16.0	9.0	0.817	.976 - .366
1979	5/30 - 8/ 2	4.5	16.0	9.0	0.933	1.457 - .329
1980	5/30 - 8/15	4.5	18.0	9.0	1.067	1.646 - .335

Appendix Table 3. Smolt distribution from raw sonar counts, by array and year, Wood River.

Year	Percentage of Total Counts			
	Array I	Array II	Array III	Array IV
1975[1]	68.6	31.4	-	-
1976	49.0	30.2	11.7	9.1
1977	36.0	24.4	20.8	18.8
1978	28.6	29.7	25.6	16.1
1979	17.0	27.1	33.1	22.8
1980	34.1	35.2	20.5	10.2

[1] Only two arrays were used in 1975.

Appendix Table 4. Comparison of Wood River smolt sonar counts vs. fyke net catches behind Array I, 1980.

Date	Time	Minutes fyke net fished	Number of smolt	Number of sonar counts[1]	Smolt/Count
7/ 3- 4	2115-2130	15	404	116	3.48
	2130-2145	15	0	27	-
	2145-2200	15	148	133	1.11
	2200-2215	15	668	254	2.63
	2215-2230	15	563	279	2.02
	2230-2245	15	1,194	468	2.55
	2245-2300	15	813	294	2.77
	2300-2315	15	2,078	677	3.07
	2349-2350	1	594	603	0.99
	0015-0020	5	4,981[2]	1,897	2.63
	0030-0035	5	2,688[2]	598	4.49
Total or Mean		131	14,131	5,346	2.64
7/11-12	2245-2300	15	1	0	-
	2300-2315	15	13	6	2.17
	2315-2330	15	2	0	-
	2330-2345	15	1	1	1.00
	2345-2400	15	4	0	-
	2400-0015	15	14	4[3]	3.50
	0015-0030	15	45	60[3]	0.75
Total or Mean		105	80	71	1.12
7/15	2255-2300	5	2,154	1,247	1.73
	2300-2305	5	4,654[1]	1,685	2.76
Total or Mean		10	6,808	2,932	2.32

[1] Counts adjusted for river velocity, but not expanded by (5).

[2] Not actual counts; derived by sub-sampling.

[3] Counts influenced by rain.

1980 SNAKE RIVER SOCKEYE SALMON SMOLT STUDIES

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INTRODUCTION

Lake Nunavaugaluk was chosen as the site for a sockeye salmon *(Oncorhynchus nerka)* fry production facility to supplement severely depressed natural production. Preliminary studies on the lake were initiated in 1974 to estimate the number of sockeye salmon juveniles that the lake was capable of supporting. While these studies identified the location and extent of important shallow water rearing areas, no estimate was made of how many fry the lake could support (Jaenicke, Mattson, and Hoffman 1978). The number and age of sockeye salmon smolts migrating from the lake was determined to evaluate freshwater survival and production of sockeye salmon juveniles. Unfortunately, estimates of the total number of smolts leaving the lake were not considered to be reliable since fyke net sampling could not be initiated until after the lake was ice-free. It was hypothesized that 50% of the total migration had occurred prior to this time (Thomason and Jaenicke 1979).

METHODS AND MATERIALS

During ice breakup in 1980 smolt sampling was conducted at two sites near the outlet of Lake Nunavaugaluk. Outlet width was about 100 m and water depth ranged from 1.5 m to 3.7 m. After ice breakup smolt sampling was conducted within Snake River, about 100 m below the outlet. River characteristics were measured in 1979 and were as follows: river width approximately 45 m, depth ranged from 0.3-0.9 m, and current speed varied from 2.9-4.9 fps. This site was the same used in all previous Lake Nunavaugaluk smolt studies (Fried and Laner 1980; Thomason and Jaenicke 1979).

During ice breakup smolt were captured using sinking variable mesh (3.8, 3.2, 2.5, 1.9, and 1.3 cm square mesh) multifilament gill nets. Two gill nets were fished continuously from 2100 hours 17 May until 0800 hours 18 May. Arctic char *(Salvelinus alpinus)*, also captured, were examined to determine whether they had been feeding upon sockeye salmon smolt.

Fyke net sampling was conducted from 18 May until 17 June using 1.2 x 1.2 m nets fitted with floating live boxes. Between 18 May and 15 June each sampling day consisted of four 1-hour periods (2300-2400, 2400-0100, 0100-0200, and 0200-0300 hours) and one 20-hour period (0300-2300 hours). Since spatial distribution of smolts across the width of the river was not known,

three locations were fished at the sampling site: one in mid-river and one near each river bank (Figure 1). A single location was fished during each period of a sampling day. The actual sampling schedule was determined prior to the field season by randomly assigning one of six combinations of location and period to each sampling day (Appendix Table 1). The fyke net was fished for 6 minutes at the assigned location during each of the 1-hour sampling periods. The net was fished continuously at the assigned location during the 20-hour sampling period. Seven 20-hour sampling periods (18, 19, 20, 23, 25, 28, and 29 May) were not fished continuously because of accumulation of debris within the net. On 17 June an index fyke net was fished continuously at Site 3. Catches made between 18 May and 15 June were used to estimate actual number of migrating smolt. Catches made before and after these dates were used as migration indices.

Upon completion of each fyke net sampling period all smolt were removed from the live box, transported to shore in buckets, counted, and placed in a holding pen. Toward the end of each sampling day a random sample of 20 smolt was taken from the pen, anesthetized with tricaine methanesulfonate, measured for fork length, weighed (after blotting dry), and a scale smear taken. On days when the total catch was less than 20 smolt, all smolt in the pen were sampled. All smolt were returned to Snake River, below the fyke net fishing site, prior to the start of each new sampling day.

Total smolt emigration from 18 May until 15 June was estimated using the following formula:

$$T = 1/W\ (60/p \sum_{i=1}^{4} \sum_{j=1}^{d} n_{ij} + \sum_{j=1}^{d} n_{5j}\ ),$$ where

T = total number of smolt leaving lake during sampling season,

W = proportion of total river width covered by fyke net = 0.049,

p = number of minutes fished during an hourly sampling period = 6,

d = number of days in sampling season = 48, and

n_{ij} = number of smolt captured in the j^{th} day during the i^{th} sampling period.

Smolt scales were mounted on glass microscope slides in the field and later viewed under a microfiche reader. Scale patterns were interpreted using criteria developed by Thomason (1979) for Snake River sockeye salmon smolt. To estimate age composition, mean length, and mean weight for the total smolt migration, the sampling season was divided into three periods of 8 days duration, and one period of 5 days duration. Age composition by period was estimated from scale samples. These values were then multiplied by the total smolt migration estimates for corresponding periods to obtain the estimated number of each age class present by period. A seasonal total for each age class was obtained by adding all period totals. Mean length and weight for each age class by period were calculated in a similar manner, and weighted by period totals to provide a seasonal mean.

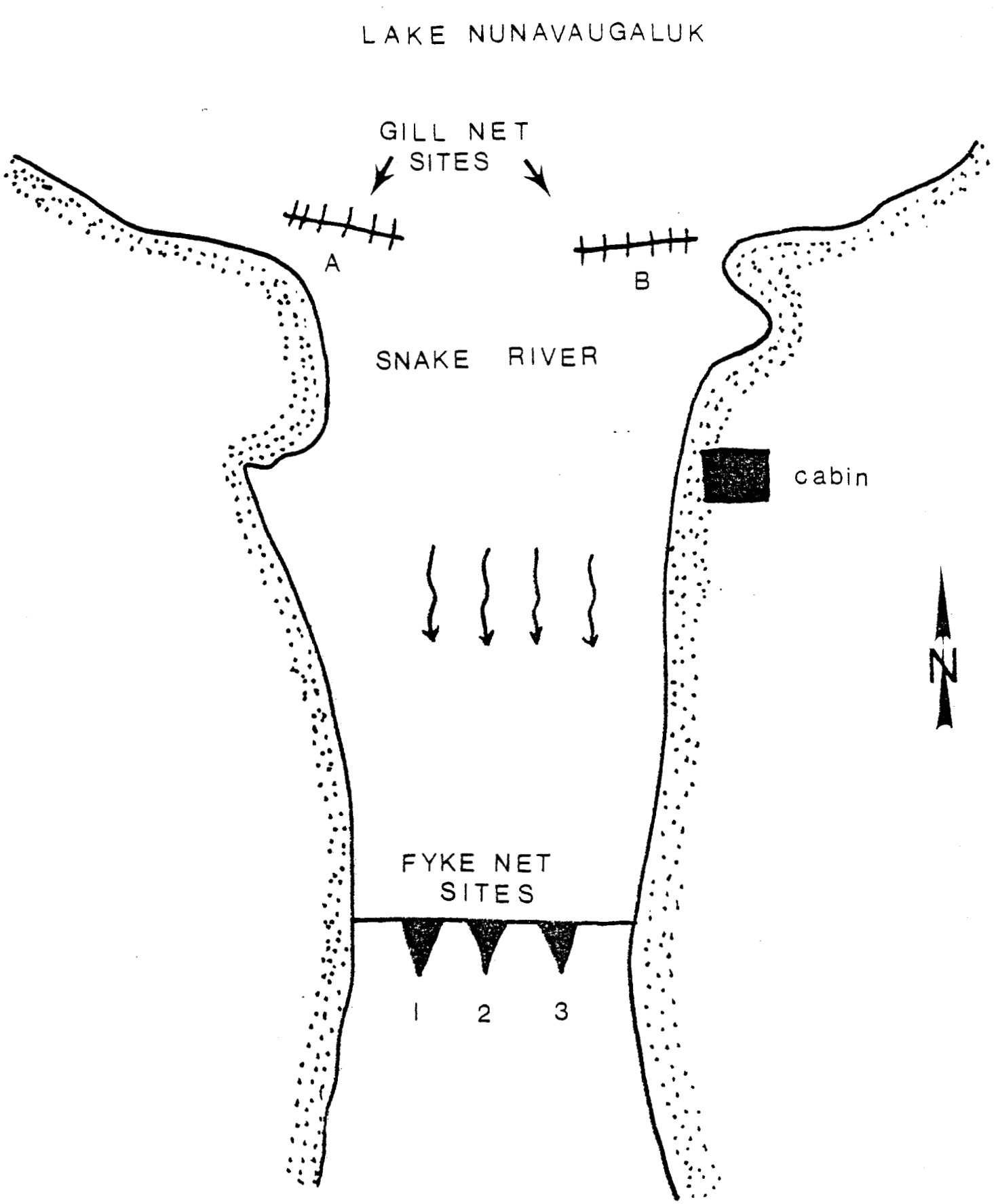

Figure 1. Area where Lake Nunavaugaluk drains into Snake River showing location of gill net and fyke net sampling sites for sockeye salmon smolts.

RESULTS

Climatological and Hydrological Observations

Daily water temperatures recorded from Snake River near the outlet of Lake Nunavaugaluk are presented in Table 1. Maximum and minimum seasonal water temperatures were 7°C and 4°C, respectively, with a seasonal mean of 4.8°C. All temperatures were recorded between 2400 and 0100 hours.

Outmigration Estimate

Six sockeye salmon smolt and eight Arctic char were captured in index gill nets during thenight of 17-18 May. All sockeye smolt were Age I. No sockeye smolt remains were found in any char stomach. Small catches of smolt and the absence of smolt remains in char stomachs suggests only small numbers of smolt left the lake before ice-out.

Fyke net sampling to estimate total sockeye smolt outmigration began at 2300 hours 18 May and continued until 2300 hours 15 June. An estimated 1,972,102 sockeye salmon smolt migrated seaward during this time period (Table 2). Peak migration occurred on 20 May and represented 22% of the total migration. Approximately 84% of the total smolt catches occurred between 18 May and 3 June (Figure 2). Nearly 80% of the smolt catches occurred between 2400-0200 hours (Table 3). Water temperature during the peak of smolt migration ranges from 4.2° to 5°C with a mean of 4.5°C.

Smolt production per spawning adult was 109.2 Age I smolt and 2.53 Age II smolt (based upon escapements of 18,074 in 1978 and 9,304 adults in 1977). These figures represent a minimum smolt production of 129.7 smolt per spawner from the 1977 brood year escapement.

Age-Weight-Length

A total of 514 smolt was sampled to determine mean weight, length, and age composition. Ninety-nine percent of the total estimated migration consisted of Age I smolt (Table 2). Peak migration of both Age I and Age II smolt occurred on 20 May.

Mean lengths were 105 mm for Age I smolt and 129 mm for Age II smolt. Mean weights of Age I and Age II smolt were 10.1 g and 18.0 g, respectively (Table 4). These compare to a 7 year mean of 94.1 mm and 7.4 g for Age II smolt; 11.5 mm and 12.7 g for Age II smolt. Annual mean lengths and weights from 1973 through 1980 are presented in Table 5.

Table 1. Surface temperatures recorded from Snake River, near Lake Nunavaugaluk outlet, during fyke net sampling for sockeye salmon smolts in 1980.

Date	Temp. (°C)	Date	Temp. (°C)
May 18/19	4.0	June 3/ 4	5.0
19/20	4.2	4/ 5	4.5
20/21	5.0	5/ 6	4.0
21/22	4.5	6/ 7	5.0
22/23	4.8	7/ 8	5.8
23/24	4.8	8/ 9	5.5
24/25	4.0	9/10	5.0
25/26	3.8	10/11	4.8
26/27	4.0	11/12	4.8
27/28	4.0	12/13	5.0
28/29	4.5	13/14	7.0
29/30	4.0	14/15	6.0
30/31	4.0	15/16	6.0
31 June 1	4.5	16/17	5.0
1/ 2	4.8	17/18	4.5
2/ 3	4.8		
		Mean	4.8

Table 2. Sockeye salmon smolt migration estimates by age class grouped by sample periods from Snake River, 1980.

Date	Number Age I	Number Age II	Total Number	Sample Size	Percent Age I	Percent Age II
May 18 - 25	1,050,620	21,441	1,072,061	160	98	2
May 25 - June 2	659,857	0	659,857	160	100	0
June 3 - 10	204,769	2,068	206,837	124	99	1
June 11 - 15	33,347	0	33,347	70	100	0
TOTALS	1,948,593	23,509	1,972,102	514	99	1

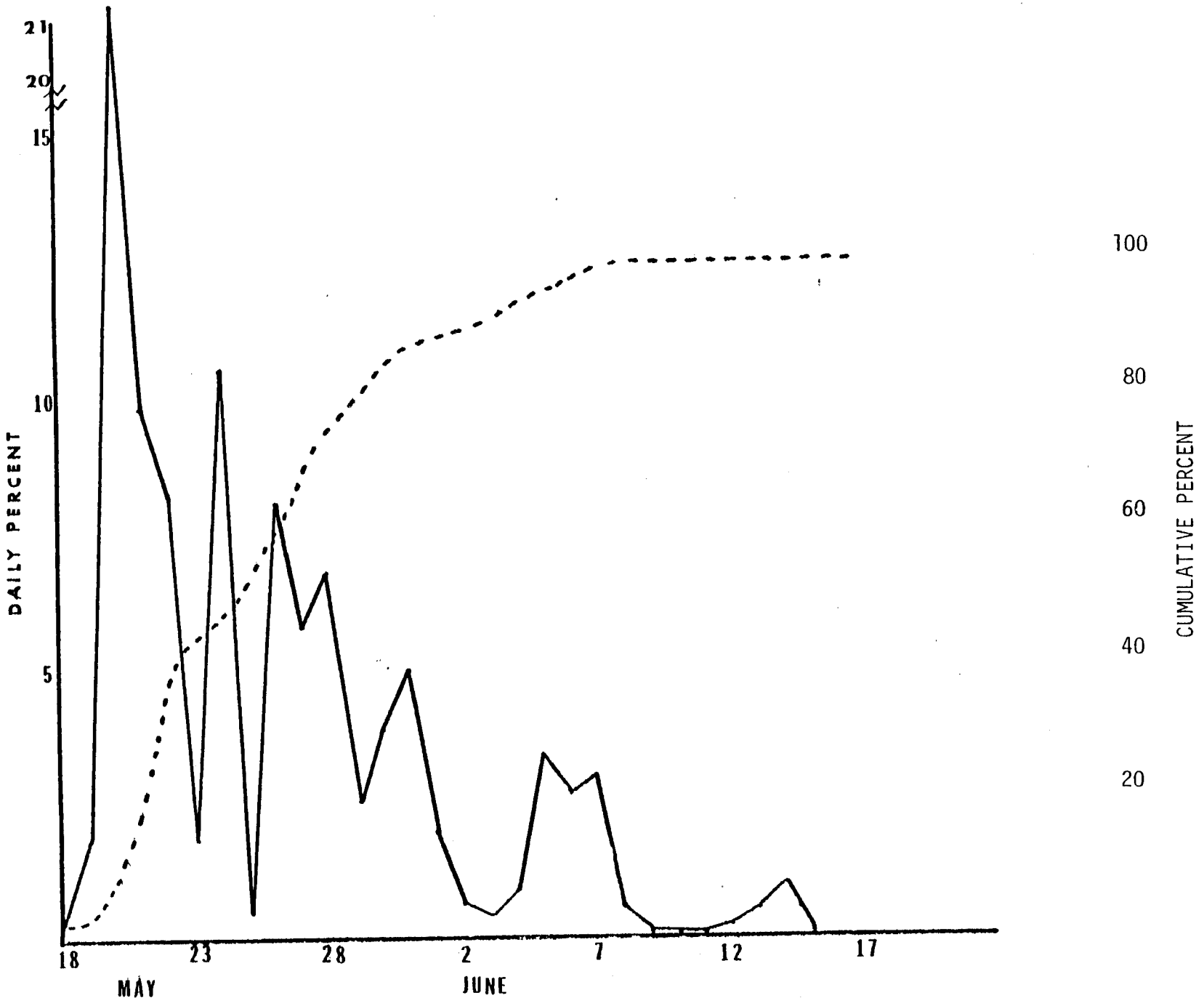

Figure 2. Daily and cumulative percent of total sockeye salmon smolts migrating from Lake Nunavaugaluk between 18 May and 15 June 1980.

Table 3. Fyke net catches of sockeye salmon smolts, Snake River, 1980.

DATE	CN [1]	CATCH PER TIME PERIOD [2] 2300-2400	2400-0100	0100-0200	0200-0300	0300-2300	DAILY TOTAL
MAY							
18/19	4	0	70	110	10	2	192
19/20	6	20	1,740	60	20	6	1,846
20/21	5	1,380	5,030	10,570	3,320	223	20,523
21/22	3	480	3,740	4,010	1,050	290	9,570
22/23	6	260	3,740	3,610	170	70	7,850
23/24	6	0	1,790	100	40	68	1,998
24/25	2	450	3,860	5,070	530	66	9,976
25/26	4	70	370	110	20	6	576
TOTALS		2,660	20,340	23,640	5,160	731	52,531
MAY							
26/27	5	100	2,420	1,360	3,340	308	7,528
27/28	1	50	2,180	3,010	120	14	5,374
28/29	6	50	3,560	2,150	730	27	6,517
29/30	1	220	480	1,340	70	10	2,120
30/31	5	20	200	870	2,520	85	3,695
31/JUNE 1	2	120	3,440	930	70	219	4,779
1/2	4	60	580	810	350	32	1,832
2/3	2	210	30	200	20	28	488
TOTALS		830	10,890	10,670	7,220	723	32,333
JUNE							
3/4	1	10	40	140	50	3	243
4/5	3	0	420	120	120	9	669
5/6	6	10	170	1,060	1,800	148	3,188
6/7	2	0	210	1,980	90	329	2,609
7/8	1	0	1,650	1,010	170	15	2,845
8/9	4	20	250	130	110	1	511
9/10	3	20	10	20	0	0	50
10/11	1	0	20	0	0	0	20
TOTALS		60	2,770	4,460	2,340	505	10,135
JUNE							
11/12	3	0	0	30	20	0	50
12/13	5	0	0	190	10	0	200
13/14	2	0	80	230	40	9	359
14/15	1	0	250	530	100	4	884
15/16	6	10	110	20	0	1	141
TOTALS		10	440	1,000	170	14	1,634

[1] Combination number: specific fyke net locations fished, per Appendix Table 1.

[2] Catches shown are hourly estimates based upon 6 minutes of sampling per hour.

Table 4. Mean length (mm), mean weight (g), variance (s^2), and sample size (n), for sockeye salmon smolts grouped by sample periods and age class from Snake River, 1980.

	AGE I					AGE II				
Date	Mean Length	s^2	Mean Weight	s^2	n	Mean Length	s^2	Mean Weight	s^2	n
May 18 - 25	107.69	32.92	10.99	3.28	157	130.0	25.0	18.6	7.87	3
May 26 - June 2	103.34	46.43	9.30	3.50	160	---	----	----	----	-
June 3 - 10	101.93	48.03	8.81	3.26	123	107.0	----	10.4	----	1
June 11 - 15	96.77	45.43	7.49	2.53	70	---	----	----	----	-
Mean[1]	105.00		10.10			129.0		18.0		

[1] Weighted by estimated number of Age I and II smolts migrating during each sampling period.

Table 5. Mean lengths and weights of sockeye salmon smolt from Snake River, 1973-1980.

Year[1]	AGE I		AGE II	
	Fork Length (mm)	Weight (g)	Fork Length (mm)	Weight (g)
1973	92	6.7	122	11.8
1974	92	7.3	-	--
1975	94	8.0	105	10.1
1976	91	6.3	-	--
1977	96	8.0	-	--
1978	93	6.8	104	9.4
1979	101	9.0	131	14.5
1980	105	10.1	129	18.0

[1] Data for 1973-1978 from Thomason and Jaenicke (1979).

LITERATURE CITED

Fried, S.M. and J.J. Laner. 1980. 1979 Snake River sockeye salmon smolt studies. In 1979 Bristol Bay sockeye salmon smolt studies. (Ed. C. Meacham). Alaska Department of Fish and Game, Technical Data Report No. 46, p. 38.

Jaenicke, H.W., C.R. Mattson, and M.A. Hoffman. 1978. Depth, substrates, vegetation, and water turbulence in the shallow waters of Lake Nunavaugaluk, Alaska, and their implication in hatchery management. National Marine Fisheries Service, Manuscript Report, MR--F No. 149, 62 pp.

Thomason, G. 1979. A comparison of Snake River adult sockeye salmon scale readings and recommendations for improving the accuracy of scale aging. National Marine Fisheries Service, Manuscript Report, MR--F No. 158. 37 pp.

_____ and H.W. Jaenicke. 1979. Snake River sockeye salmon smolt studies, 1973-1978. National Marine Fisheries Service, Manuscript Report, MR--F No. 161. 80 pp.

Appendix Table 1. Key to daily fyke net position.

Arrangement Number	Net Location (see Fig. 1) 1	2	3	Fishing Time: Start	End	Associated Sampling Time
1	X			11:30 pm	11:36 pm	11:00 pm to Midnight
		X		12:30 am	12:36 am	Midnight to 1:00 am
			X	1:30 am	1:36 am	1:00 am to 2:00 am
	X			2:30 am	2:36 am	2:00 am to 3:00 am
			X	3:00 am	11:00 pm	3:00 am to 11:00 pm
2		X		11:30 pm	11:36 pm	11:00 pm to Midnight
	X			12:30 am	12:36 am	Midnight to 1:00 am
			X	1:30 am	1:36 am	1:00 am to 2:00 am
	X			2:30 am	2:36 am	2:00 am to 3:00 am
		X		3:00 am	11:00 pm	3:00 am to 11:00 pm
3			X	11:30 pm	11:36 pm	11:00 pm to Midnight
		X		12:30 am	12:36 am	Midnight to 1:00 am
	X			1:30 am	1:36 am	1:00 am to 2:00 am
			X	2:30 am	2:36 am	2:00 am to 3:00 am
	X			3:00 am	11:00 pm	3:00 am to 11:00 pm
4	X			11:30 pm	11:36 pm	11:00 pm to Midnight
			X	12:30 am	12:36 am	Midnight to 1:00 am
		X		1:30 am	1:36 am	1:00 am to 2:00 am
		X		2:30 am	2:36 am	2:00 am to 3:00 am
			X	3:00 am	11:00 pm	3:00 am to 11:00 pm
5		X		11:30 pm	11:36 pm	11:00 pm to Midnight
			X	12:30 am	12:36 am	Midnight to 1:00 am
	X			1:30 am	1:36 am	1:00 am to 2:00 am
			X	2:30 am	2:36 am	2:00 am to 3:00 am
		X		3:00 am	11:00 pm	3:00 am to 11:00 pm
6			X	11:30 pm	11:36 pm	11:00 pm to Midnight
	X			12:30 am	12:36 am	Midnight to 1:00 am
		X		1:30 am	1:36 am	1:00 am to 2:00 am
		X		2:30 am	2:36 am	2:00 am to 3:00 am
	X			3:00 am	11:00 pm	3:00 am to 11:00 pm

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